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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 135.

SORGHUM SIRUP MANUFACTURE.

BY

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.

1901.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
Washington, D. C., May 19, 1901.

SIR: I submit herewith, for your inspection and approval, the manuscript of Farmers' Bulletin No. 135, prepared by your authority, under my direction, by Mr. A. A. Denton, of Medicine Lodge, Kans. It is designed to take the place of Farmers' Bulletin No. 90, issued in 1899, considerable new and valuable information having since been received.

Mr. Denton has devoted many years to the experimental study of the simplest and most effective methods of clarifying sorghum juices and sirups in order to secure a high-grade product. The later results of his experiments are described in the present bulletin.

The annual production of sorghum sirup in the United States is about 25,000,000 gallons, of a value of at least \$10,000,000. If a better clarification of the raw materials could be secured, it is evident that the demand for this wholesome product would be greatly increased and the production correspondingly enlarged. Mr. Denton's bulletin is a practical contribution to this desired end.

Respectfully,

H. W. WILEY,
Chief of Division of Chemistry.

HON. JAMES WILSON,
Secretary of Agriculture.

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SORGHUM SIRUP MANUFACTURE.

INTRODUCTION.

Farmers' Bulletin No. 90 contained results of experimental work in sorghum-sirup manufacture by the writer to the time it was written. The present bulletin contains the results of subsequent experimental work in the same line, though it is not now considered complete. There is much promise of general improvement in the quality of sorghum sirup as the result of further experimental work, and this bulletin, not intended as a complete treatise on sorghum-sirup manufacture, deals almost exclusively with the improving of the sirup by removing impurities from the juice.

The methods described have special reference to small sirup factories which have only the simplest apparatus. Promising processes suited only to well-equipped steam sirup factories are not discussed. By far the greater part of the 25,000,000 gallons of sorghum sirup produced annually is made in horsepower mills having only the simplest facilities. In trying to lift the sorghum-sirup industry from its present depressed condition the first step should be to assist the tens of thousands of primitive sirup factories to make a general and considerable improvement in the quality of their sirup.

The processes described do not require expensive apparatus, dangerous chemicals, or expert skill. Probably most sirup makers, used to making sirup by merely boiling and skimming, will consider these processes too troublesome. But there are some who desire to make superior sirup which will please the consumer and the maker, and which will be in greater demand at higher prices. The fact that sorghum sirup is now made by few and simple processes is evidence that the manufacture is unperfected. The tendency of all modern manufacturers is toward increasingly complex methods and a better product. The manufacture of golden sirup, and also of glucose sirup, has as many as ten processes. It seems to pay to use as many as improve the sirup.

Many processes in sirup manufacture were tested first in a laboratory way, using juice from a handmill. The successful processes were again tested in a larger way, using juice from a horse mill. The processes recommended here have been repeatedly verified, using all grades of sorghum juice.

Any sirup maker who may try the processes described here, even with only a panful of juice over a cook stove, settling in a clear glass bottle, so as to see the results, is asked to inform the writer of his conclusions.

SOIL AND CLIMATE AS AFFECTING QUALITY OF SIRUP.

Sorghum sirup is produced in forty-four States and Territories. Hundreds of samples of sirup have been collected from all parts of the country for comparison. So far as can be judged from numerous samples, the States which border on the Gulf, where the annual rainfall is 70 inches, often produce inferior sorghum sirup. The States of the plains, the semiarid section, where the annual rainfall is 20 to 30 inches, generally produce inferior sirup. The best sirup is produced where the growing seasons are more uniformly favorable, neither too wet nor too dry, and on soils of moderate fertility. A good growing season, followed by a moderately dry ripening season, seems best in any section. An even and proper supply of moisture appears to be much more important than the nature of the soil. In a very dry season rich and moist lowlands often produce the best sirup. In a wet season arid and poor uplands often produce the best sirup. It is probably true that almost any soil, in any section of the country, with suitable rainfall, can produce good sirup. And it is probably also true that by separating well the colorless solution of crystallizable sugar and of uncrystallizable sugar, which sorghum juice always contains, from the vegetable impurities, good sorghum sirup can be made in any section with cane from any soil. Canes of quick growth usually produce good sirup; for, to ripen unusually soon, the entire growing season must be unusually favorable, producing naturally pure juice, and thus, naturally pure sirup. Unfitness of sorghum juice for sirup making increases as canes become ripe or overripe. For these reasons sirup made in the far North is usually of better color, of milder flavor, and more palatable than sirup made in the South. Nebraska, Kansas, Oklahoma, and the part of Texas south of these States, produce the largest acreage of sorghum and the cheapest cane; the canes produce denser, richer juice, but often less pure, and consequently inferior sirup to that of States less subject to extremes of drought and flood. In Kansas the amount of true sirup-making material, the sum of the crystallizable and of the uncrystallizable sugar, varies less from year to year than the yield of wheat or of corn. The juice usually contains quite as much of these two sirup-making materials as Louisiana sugar-cane juice, yet it often produces sirup of poor quality, because it is often loaded with slimy and suspended impurities, which are not well separated from the juice by the processes of sirup making now in use. The climate and the nature of sorghum can not be changed. Western

sirup makers need to take more pains to grow good cane and to use better methods for cleaning the juice from its impurities. The generally inferior quality of Kansas sirup is not caused by the soil, for in favorable seasons it produces as good sirup as any section. It is not due to the lack of good sirup-making material in the juice, but to the excess of impurities present. When the juice is well purified it always gives good sirup. The special object of this bulletin is to show how the vegetable impurities which give sorghum sirup its dark color, rank flavor, and turbid appearance may be removed, so that better sirup may be always produced in any section or locality.

VARIETIES OF SORGHUM SUITED TO DIFFERENT LOCALITIES.

Sorghum has been cultivated in this country for fifty years, yet no general selection of the best varieties for sirup making has been made. Extensive correspondence with sirup makers in all sections shows no general preference for any variety except Early Amber for early maturing cane. In Kansas the most frequent preference is for the varieties which produce the most seed; for sorghum seed is a valuable product. The fact that sorghum has been grown long and extensively with very little selection of varieties has not been due to lack of intelligence on the part of sirup makers, but to the variable amount from year to year of the impurities in the juice of all the varieties. A variety may be selected in one season because it produces good sirup; it may be rejected the next season because it produces poor sirup. Planted early it may produce good sirup, and when planted late it may produce poor sirup in the same season and on the same soil, yet in both seasons it may produce ample and good sirup-making material. The impurities vary in amount, according as the growing seasons are favorable or unfavorable. If the impurities are not well removed from the juice, a part remains mixed in the sirup, and so if the juice is naturally pure the sirup is pure; if the juice is impure the sirup is inferior. This variable quality of sorghum sirup will continue until sirup makers remove the impurity which causes the variations. If two samples of good wine are to be compared, to one of which impurity like that in sorghum juice has been added,



FIG. 1.—Seed heads of Early Amber sorghum.

then the two samples can not be rightly compared until the impurity has been well removed. The same is true of two samples of sirup from two varieties of sorghum. When both samples have been refined, so that they are equally pure, then selection can be made of the best variety, and then the excessively variable quality of sorghum sirup from year to year will be largely done away with. Removal of all the impurities from the juices of 100 varieties of sorghum would

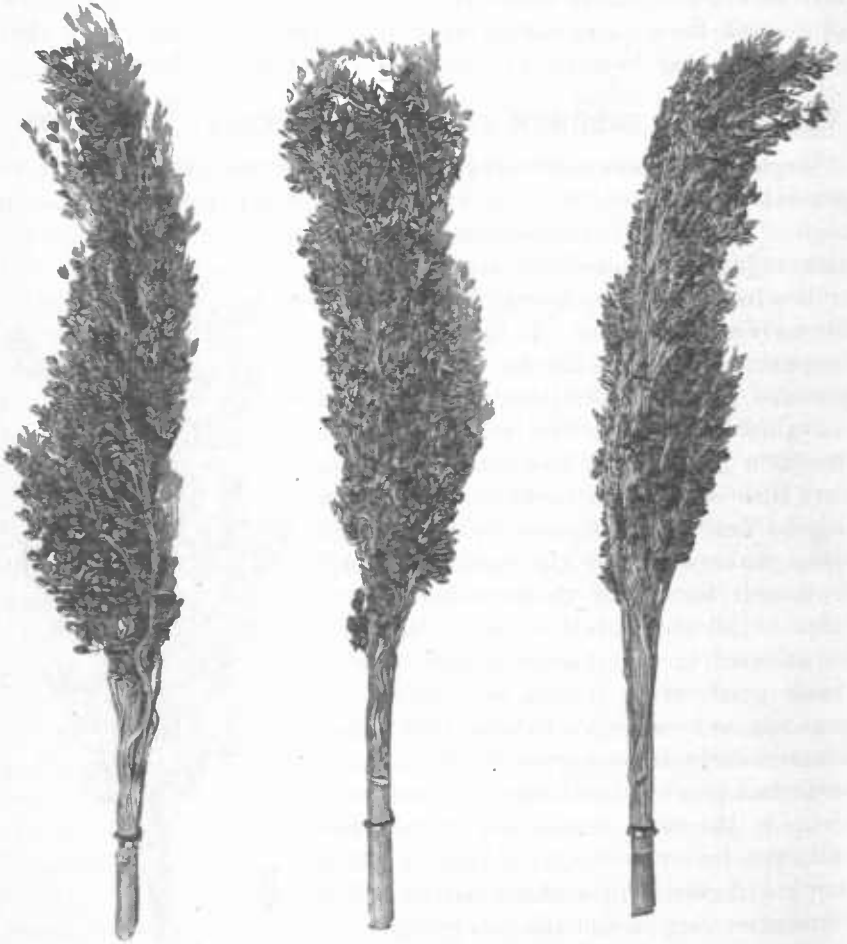


FIG. 2.—Seed heads of the Collier variety of sorghum.

show the true quality of each, and would surely lead to the selection of a few varieties superior in flavor or other quality.

For eight years careful search was made among hundreds of varieties of sorghum for a variety which would usually give as pure juice as that from sugar cane. Such a variety has not been found. In the past three years the effort has been made to find ways of separating the excess of impurity from sorghum juice, so as to make it as pure as

sugar-cane juice naturally is. There is much promise in this line of work. When that is accomplished, selection of superior varieties can be made. At present no one can rightly name the best varieties for any section or locality, except Early Amber for early maturing cane.

But three varieties are recommended here: Early Amber (fig. 1), the best early variety; Collier (fig. 2), the richest in sugar, and Colman (fig. 3), which produces good juice, larger, shorter canes, and more seed than the others.

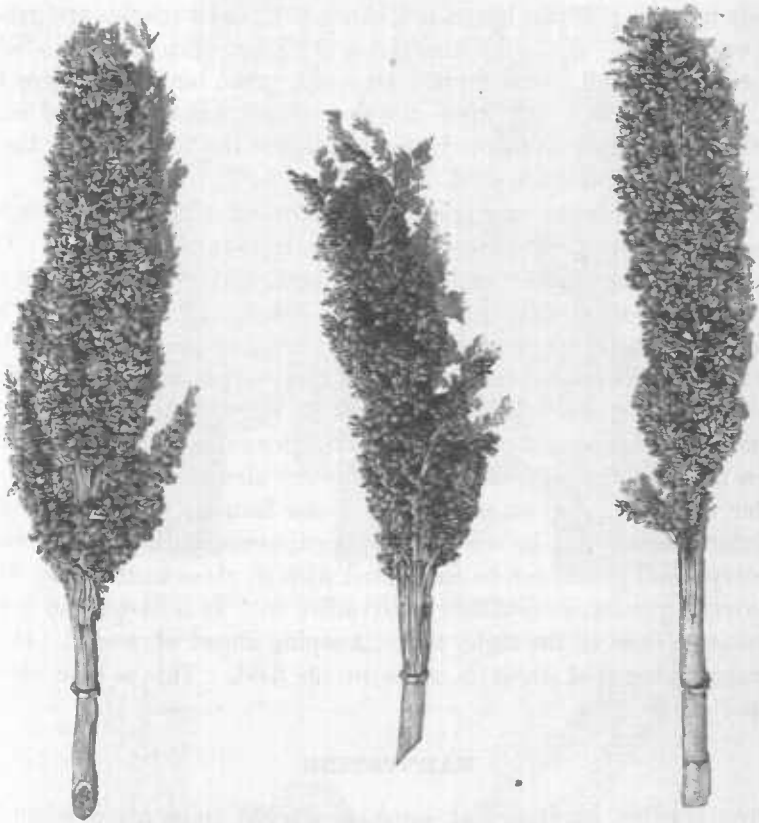


FIG. 3.—Seed heads of the Colman variety of sorghum.

PLANTING, CULTIVATING, AND HARVESTING.

Securing good, unmixed seed, of a good variety, is the first step toward making good sirup. A sirup maker should select typical canes of the varieties he prefers and put them in shock. The seed keep well there, unless taken by birds or stock, and should remain until they can be attended to. When quite dry, a dozen or more of the seed heads should be put into a stout grain bag. Pounding the heads with a club quickly thrashes the seeds. The seeds may be cleaned in the

wind by pouring them from one pan into another, then shaking the pan to bring stems and trash to the surface, so that they can be removed. A sirup maker may thus obtain unmixed seed of a good variety, sounder, cleaner, and better than he can buy.

PLANTING AND CULTIVATING.

A pound and a half of sound seed is enough to plant an acre. A bushel weighs 56 pounds. Some varieties ripen in three months, some in four months. When harvested, canes of mixed varieties are green, ripe, or overripe—all are not in best condition for sirup making. Some varieties grow tall, some short. In topping the bundles of cane the seed heads are often left upon the short canes, causing loss of seed, and the seeds which go through the mill injure the sirup. It is therefore better to plant pure seed.

In times of drought canes planted thickly suffer more and give less pure juice. In the West most sirup makers plant too thickly. One cane in 6 inches of the row is quite enough, and with good seed one seed in each 3 or 4 inches of the row is sufficient. The planting and cultivating are often carelessly done. Cane and sugar-beet planters take vastly more pains in cultural work than sorghum growers. More care in planting and cultivating sorghum would often give a much larger yield of cane and better juice, all other expense being the same. Often much of the cane brought to Western sirup mills is more fit for fodder than for sirup manufacture. Some farmers who use the disk cultivator assert that its use is almost indispensable in growing cane; for very small plants can be cultivated with it, close to the row, without covering them, as ordinary cultivators do. It is easier and better to cultivate cane at the right times, keeping ahead of weeds. It is a German saying that sugar is made in the field. This is true also of sirup.

HARVESTING.

Cane is often harvested at some convenient time, often when too green or overripe. It should be cut when in best condition for sirup. Topping the seed heads is often badly done, leaving much seed to go through the mill and into the juice. Good dyes can be made from sorghum-seed hulls, and starch from the seeds; hence the importance of keeping the juice as free as possible from these substances. The good canes only used to be stripped of leaves and brought to the sugar mill; now everything in the row—weeds, broken canes, suckers, etc.—are milled and serve to make sirup, since machine harvesters take all, and the mill grinds all. It is not economical to take excessive pains in manufacture, but it does pay to do work in a workmanlike manner—at the right time and in the right way.

GRINDING CANE.

There is a great loss of juice in grinding sorghum cane. The stalks are smaller and softer than sugar cane, yet the same mills and power



FIG. 4.—Heavy three-roll, vertical, horsepower cane mill

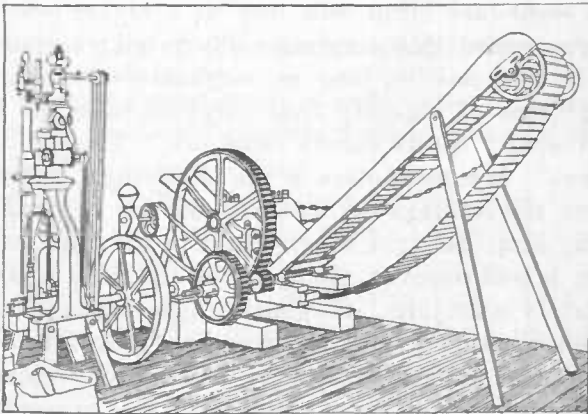


FIG. 5.—A small steam cane mill, with vertical engine and carrier for crushed cane.

extract less of the juice from sorghum. When the work to be done justifies the expense, it is better to get a first-class mill from first-class mill makers. It should be well set up. It is well to “anchor” each

post with wire rope, as corner posts in wire fences are often anchored, to steady the mill against the twisting strain.

In the semiarid region canes are often hard and woody, wilted and dried, and grind harder than fresh, juicy canes, causing greater loss of juice. A mill should give 60 per cent of the weight of the cane in juice; that is, 1,200 pounds of juice from 2,000 pounds of cane. A small horse mill can give as good extraction of juice as a massive mill driven by a powerful engine. Even a hand mill can give an average extraction of 60 per cent. Many sorghum mills give less. With as good extraction of juice as is got from sugar cane or sugar beets a ton of sorghum cane of average quality yields 20 gallons of sirup; but this can not be secured with single mills. (See figs. 4 and 5.)

CLARIFICATION.

Sugar-maple sap is one of the purest natural saccharine liquids. Sugar-cane juice is less pure and sorghum juice is much less so. Their sirups rank in this order. When these three sirups are refined, as sugar refiners refine golden sirup, they have like qualities and equal values. The maple sirup loses its peculiar flavor, the sugar-cane sirup loses some of its impurities and its characteristic qualities, and sorghum sirup loses the excess of impurity which makes it inferior. Sugar-cane juice has about $1\frac{1}{2}$ per cent of solid matter not saccharine. Sorghum juice has much more. The amount of crystallizable and uncrystallizable sugar is not usually less in sorghum juice. The mineral matter differs in no essential respect. The essential difference, so far as sirup making is concerned, is in the amount of vegetable impurity.

Unmixed sugar-cane sirup sells now at a higher price and is in much greater demand than sorghum sirup in all wholesale markets. This will be the case so long as sorghum-sirup makers fail to remove the excess of impurity from sorghum juice and leave it in the finished sirup. Sirup makers often say, "The quality of sirup is in the juice." It is more often in the clarifying. It can be shown that the scum and settlings and inferior juice can be purified so as to make a better sirup than from the best juice by the usual way. Unless the impurity is well removed, the quality of the sirup is as variable as was the impurity in the juice. Sorghum sirup is now, as always, quoted in wholesale markets at a much wider range of prices than sugar-cane sirup. When the impurity remaining in finished sorghum sirup is removed it tastes like sorghum scum, and is due to scum which was not removed. When none of the impurities are removed from sorghum juice the sirup is objectionable; when well removed the sirup is good; when perfectly removed the sirup is first class, and as good as any cane sirup. A part of the impurity can be removed from sorghum

juice by clarifying the raw juice before heating to the boiling point; a part by clarifying the hot juice; a part by skinning; a part by clarifying the semi-sirup, and, finally, by purifying the finished sirup.

PROGRESSIVE CLARIFICATION.

Sorghum juice can not be clarified well by a single process. If all the impurities which separate in the treatment of the thin juice are removed, more solid impurity is thrown out of solution by concentration to thin semi-sirup of 20° density.¹ If this impurity is removed, more impurity is thrown out of solution by concentration to heavy semi-sirup of 30° density, and a small amount of impurity is separated by the final concentration of the sirup to 36° density, hot—that of finished sirup. It follows from this fact that there must be several clarifications—first, of the raw juice, then of the hot juice, then of the semi-sirup at 25° density—in order to remove the impurities from the liquid. If not removed from the boiling liquid these solid impurities blacken and burn upon the heating surface and injure the color and flavor of the sirup. To make good sirup it is advisable to skim continuously during concentration. It is also necessary to remove from the thin juice and from the semi-sirup impurities which can not be removed by skinning alone. Good sirup can be made by skinning and settling the hot, thin juice and then skinning and settling the semi-sirup.

It is an advantage to skim and settle, then filter, the hot, thin juice, and, after concentration, to skim and settle, then filter, the semi-sirup. But a small sirup factory can make good sirup by simply skinning and settling the hot, thin juice and by skinning and settling the semi-sirup at 25° density.

CLARIFYING RAW JUICE BEFORE HEATING TO BOILING.

Mill juice contains a great excess of solid matter. These solid particles and slimes often settle upon the heating surface of the pan and discolor the juice in the first heating.

While the juice is heating, before boiling, there is no active circulation in it, and solid impurities often become colored by the intensely heated surface at the bottom of the pan. Emptying the pan sometimes shows that the hot iron is covered with slime. Even in the finishing end of the pan, while boiling well, moving a scraper over the bottom under the sirup sometimes brings up a gummy matter which

¹This and following numbers expressing density refer to the Baumé scale: 20° B.=35.7 per cent total solids; 25° B.=45 per cent total solids; 30° B.=54.3 per cent and 36° B.=65.9 per cent total solids; 36° B., hot—that is, at the temperature of boiling water, would be equivalent to 40.5° B. at 63° F., at which temperature a gallon of sirup would weigh 11½ pounds.—H. W. W.

had settled upon the heating surface. These are extreme cases, yet almost always the solid matter in sorghum juice is browned more or less by roasting upon the heating surface. This gives the sirup bad color and flavor. The remedy is to clean the juice from solid matter before heating, or to warm it so that it will settle well out of contact with very hot surfaces. A 20 per cent solution of sugar and of uncrystallizable sugar can be boiled three hours at 215° to 221° F. with little change of color. Well-cleaned sorghum juice can be boiled three

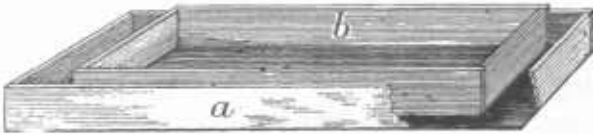


FIG. 6.—A water bath for heating juice below the boiling point.

hours without objectionable change of color. In these cases there is no solid impurity to be scorched on the heating surface.

Methods of clearing.—The method of clearing cold, raw juice, before heating, by claying and settling, was fully described in Farmers' Bulletin No. 90. The writer clarified 50,000 gallons of raw mill juice,



FIG. 7.—A "farmers' feed cooker" for heating juice by injection of steam.

in experimental work, by that process successfully. But it requires the use of heavy, coarse-grained clay, which is often not easily obtainable in some sections. It requires two hours for a small mill to grind enough juice to begin settling and two hours more to clay, settle, and decant the juice, hence the evaporator is delayed four hours in starting. The process cleans the cold, raw mill juice well before heating, but it is troublesome when fine-grained clay, or coarse clay mixed with fine clay, is used. Those sirup-makers who use suitable clay like this process. The past season an effort has been made to obviate the

difficulties of settling raw juice well before heating to boiling. Any clay, even fine river silt, settles well in hot juice and carries down the solid impurities. This process alone makes an improvement in sirup. But when heating the juice, before claying, it is often colored more or less by the heating surfaces. A water bath (fig. 6), which may consist of a wooden pan with sheet-iron bottom, inch boards for sides and ends, 8 feet long, 3 feet wide, and 8 inches deep, may serve for a water heater. Inside this pan a similar but smaller pan is floated on water, which

is heated to the boiling point. Juice in the inner pan is quickly heated to about 160° F. Sediment and slimes may settle upon the bottom of this juice heater, but do not blacken by the heat of boiling water. When heated the juice can be drawn off in a tub or barrel by a siphon or by a large flat scoop, and can then be clayed while hot, settled, and decanted. This water bath may have a furnace or may be heated by water boiled in the evaporator. A farmers' feed cooker (fig. 7), which costs about \$25, can be used for heating by blowing steam directly into a barrel filled with juice, or a wooden pan having a double sheet-iron bottom, making a "steam jacket," may be employed for heating below the boiling point (fig. 8). Those who make sirup by steam can easily warm and settle clayed juice by using a steam-jet pump, as stated in Mr. Denny's letter, appended.¹ The writer's work has been done mainly by heating the raw juice to 160° F., then claying, settling, and decanting the clear juice into the

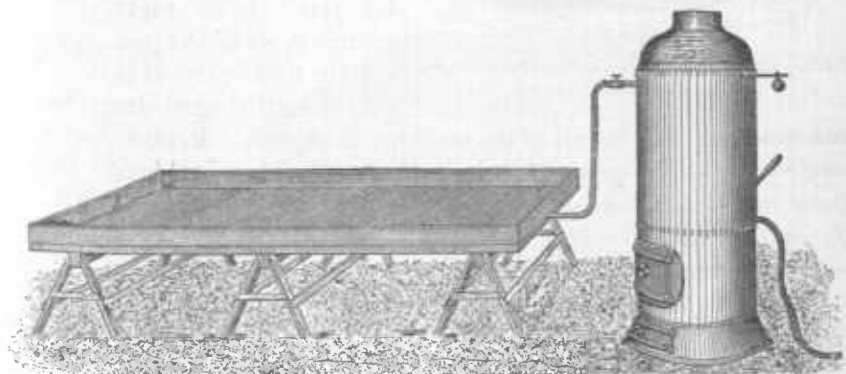


FIG. 8.—A pan with double sheet-iron bottom, for heating juice by steam at low pressure.

evaporator. It is the belief of the writer that less impurities are dissolved by heating to a low temperature than in settling them out, and also that this heating of raw juice should be continued no longer than necessary before settling, for the same reason. On drawing off the warmed juice from the heaters a surprising amount of slimy impurities is sometimes found settled upon the bottom, which partly explains the extremely variable quality of sorghum sirup when made in the usual way.

PROCESSES.

Process No. 1.—For the smallest sirup factories. A little mill, a plain wooden pan with sheet-iron bottom, a juice barrel, and a half-barrel tub are sufficient.

Grind a barrel full of juice; let it settle as long as may be; draw off the juice from the upper part of the barrel, leaving the rest to

¹See p. 37.

settle longer, taking as little turbid juice as possible. Heat the settled juice in the pan to near boiling, skim, empty it into the tub, add clay, mix well with a hoe (the juice should look clayey), let it settle half an hour to an hour, and gently pour off the settled juice. In pouring off

slowly the juice is apt to run down the outside of the tub unless it has a tin strip tacked on, as shown in figs. 9 and 21, for a pouring lip. Run the clear juice back into the pan, boil, and skim until it begins to thicken, and when the sirup is about half done empty it again into the tub, add clay as before, mix well, cover the tub to retain the heat, and let stand over night. Next morning, while the mill is grinding the first barrel of juice, pour off the settled semi-sirup slowly



FIG. 9.—A decanting tub for pouring off settled juice, leaving the settlings.

and carefully, leaving all of the settlings in the tub. Return this clean semi-sirup to the pan and boil it to sirup. Place a sample of the sirup in a clear glass bottle in a strong light for comparison. Return the settlings remaining in the tub to the juice barrel, rejecting the solid settlings, to be clarified again.

Process No. 2.—The raw juice from the mill goes directly into a long, shallow settling pan (fig. 10). Two sheets of iron, each 8 feet long and 3 feet wide, are riveted together, end to end, forming one sheet 16 feet long. This is nailed on a wooden pan of the same size, forming the bottom of the pan. In nailing on the iron, at first nail far apart all around, then between the first nails; then divide and subdivide the spaces until nailed closely enough. This puts the bottom on smoothly, not taking all the stretch of the iron at one place. Also put a wooden partition, *b*, lengthwise through the middle of the pan, leaving a pass-



FIG. 10.—A long settling pan for mill juice.

way, *e*, for juice at one end. This forms a long, shallow pan, 6 or 12 inches deep, as required, and divided into two channels, each 1½ feet wide and 16 feet long. The juice enters at one end, *d*, flows gently down one channel through the passway, *e*, and back through the other channel to the end it entered, depositing impurities as it flows along. The settled juice is drawn off at the surface of the juice by a

swing pipe, *c*, into the juice heater or pan, having traveled and settled in a trough 32 feet long. The juice should not be drawn off faster than needed, leaving it to settle as long as may be, the raw juice going into this settling pan all day and being drawn off when needed. The pan is thus a storage tank for juice and also a settling pan. It should be well washed each night. (See Mr. Semke's letter, appended.)¹ The decanted juice is now heated and treated as in process No. 1, giving a settling of cold, raw juice, a clayed settling of juice heated to boiling point, and a settling over night of the clayed semi-sirup at about 25° density. The decanted semi-sirup is reduced to sirup.

Instead of settling raw juice in the long, shallow pan, it may be filtered first through a pebble filter, *a* (fig. 11), then through a coarse sifted sand filter, *b*, and finally into the juice tank, *c*. The writer obtained a good filtration through several inches of coarse sand, the fine sand having been well sifted out, because it hinders and elogs

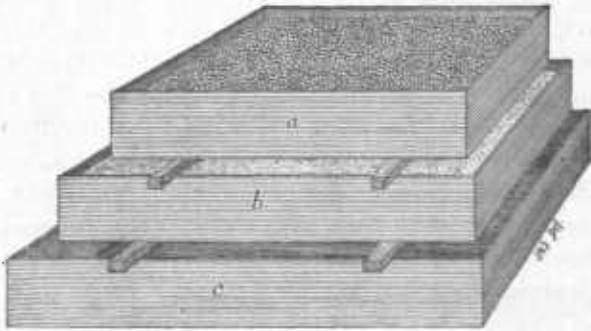


FIG. 11.—A gravel or pebble filter and sand filter over a juice tank.

the filter. But when juice is very slimy it is better to filter first through pebbles, sifted out of the sand filter; for the pebbles retain gummy foam, seeds, leaves, etc., and thus relieve the surface of the sand filter; or, better, the raw juice may be settled first in the long pan (fig. 10), then through coarse sifted sand. These filters should have sufficient surface to filter all the mill juice for half a day or for a day, or there should be two, so as to avoid interruption of work. After going through this cleaning, the juice is treated as in process No. 1. The best size grain for the sand filter seems to be about one-thirtieth of an inch; that is, 30 of the grains of sand, side by side, measure 1 inch. The filter boxes have cross slats (fig. 16), nailed a little way apart, allowing the juice to pass downward through the filtering material, in all parts of the filter, into a juice tank beneath. It is well to place wire-screen netting upon the cross slats, to better retain the sand, unless the latter is sufficiently coarse to be retained in place by the slats. The writer used closely woven gunny cloth,

¹See p. 38.

but prefers a perforated metal bottom. When clogged the sand can be washed and replaced in the filter.

Process No. 3.—Raw juice from the mill is warmed in the water bath (fig. 6), in the steam “blow up” (fig. 7), or in the “steam jacket” pan (fig. 8), and is then drawn off and clayed, settled, and decanted, then treated as in process No. 2, being clayed and settled when heated to boiling point. The semi-sirup, at 25° density, is clayed and settled overnight.

Process No. 4.—To the settled or filtered mill juice heated to nearly boiling point and skimmed, elariphos¹ is added at the rate of not more than 1 gallon to 2,000 gallons of juice; that is, 1 pint of the acid to 250 gallons of juice. Boil and skim the juice a few minutes, then carefully neutralize it with lime, a little lime added at intervals, until a piece of blue litmus paper dipped in the juice shows only a slight tinge of red. Care must be taken that the blue paper does not remain blue, which would show that too much lime, which causes the sirup to be a dark color, had been used. Also be careful that the paper when dipped in the juice does not become bright red, as this indicates that the juice is too acid; for sirup containing the free acid is never clear and is too acid to the taste. The juice is settled and decanted after liming, and the semi-sirup, at 25° density, is clayed and settled, as before. The object in adding elariphos to the juice before liming it is to form phosphates with the mineral matter. This process is not difficult for those who can use lime accurately. It improves the sirup, but very good sirup can be made without it.

It will be noticed that the object of these processes is first to remove solid impurities from the raw mill juice before heating the latter much, then to remove the impurities coagulated by heating the juice to the boiling point, and finally to remove impurities which separate during concentration of the juice to 25° density. If this is not done all of the impurities, except those which can be removed by skimming, are cooked and browned in the boiling liquid, which results in an inferior sirup. A much better sirup is made by removing the solid impurities from raw juice either by long and gentle flowing, settling in a shallow trough 32 feet long, or by filtering first through pebbles and afterwards through coarse sand; or by moderately warming the juice out of contact with very hot surfaces, then claying, settling, and removing impurities thrown out of solution during concentration of the juice to 25° density by skimming, and then claying and settling the semi-sirup.

¹ Acid phosphate of lime.

INTERMEDIATE FILTRATION.

A new method of progressive clarification has recently come into use in beet-sugar factories. It consists in filtering thin semi-sirup, and in again filtering the heavy semi-sirup through carefully sifted coarse sand, thus removing the impurities which separate during the concentration of well clarified juice. The apparatus used in this process is shown in fig. 12. The clarified juice is partly evaporated in the evaporating pan *a*. The juice then passes through the sand filter *b*, thence to the evaporator *c*, and is further concentrated, is again filtered through the sand filter *d*, and still further concentrated in the evaporator *e*. The impurities thrown out of solution in the liquid are thus removed by successive filtrations through coarse sifted sand.

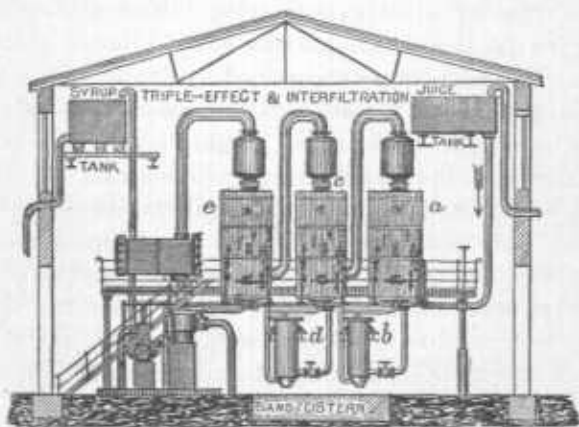


FIG. 12.—Intermediate sand filtration.

CLAYING JUICE AND SEMI-SIRUP.

Clay attaches itself to the solid impurities, weights them, and causes them to settle. Infusorial earth is preferred, but is not so readily obtained. Clay settles slowly in cold, raw juice; quickly and compactly in hot juice; slowly in semi-sirup of 25° density; more slowly in heavy semi-sirup of 30° density, and settles imperfectly in finished sirup. It is preferable to mix clay with limewater. More lime than water will dissolve would be better, but care must be taken not to use excess of lime in the clay, since it will spoil the sirup. Lime causes the particles of clay to flocculate—that is, to adhere together, and thus settle better; it also reduces the acidity of the juice in proportion to the amount used. Clay may be added to juice or semi-sirup until the density of the clayed liquid is about 2 degrees higher by the

saccharometer than it was before claying. More clay does no harm. It should be well mixed in the hot liquid. If the clay is lumpy, it is advisable to wet it several days before using to allow quicker mixing. It is to be wished that some heavier substance than clay could be found which would settle well and compactly in semi-sirup at 30° density. It seems best to settle semi-sirup with clay at about 25° density, rather less than more.

LIMING JUICE.

The acids naturally in sorghum juice often make the sirup unpleasantly acid. The market is now favorable to neutral sirups. Acids also dissolve impurities and keep them in solution, so they can not be removed by skimming, settling, or filtering. Neutralizing the acids in the juice throws the dissolved impurities out of solution so that they can be removed. Two advantages are gained by liming juice—the sirup is clearer and is less acid, but it is also a darker color. Neutral sirups have not so light a color as unlimed sirups. Sugar makers have an advantage over sirup makers, for they can lime nearly to neutrality or to alkalinity, and so get a better clarification. Sirup makers should never lime to neutrality, but only to a faint red, by the blue litmus-paper test. To the writer's taste very acid juice, even when properly limed, yields sirup of less pleasant flavor than juice of lower acidity. If the juice is not limed to neutrality it retains some free acid, and if it is limed too heavily it acquires a "bitter-sweet-sour" flavor. The cane should be worked before the juice becomes too acid.

"Book" litmus, sold by druggists, is rather expensive. Wholesale dealers sell large sheets of blue litmus paper at 5 cents a sheet. A piece should be cut off for present use, clipped into small oblong pieces, and put into a small bottle, which may be corked and carried in the pocket. The rest of the sheet should be put away in a corked bottle for future use. Acid vapors in the air and fingers moist with acid juices redden and spoil blue litmus. By moistening the tip of the finger and touching one of the pieces of the blue paper it may be picked up without handling the others.

It requires practice to lime juice well. It is better to lime lightly at first, noticing the color of the juice after the addition of lime, the tint of the blue paper after wetting it in the limed juice, and the quality of the sirup produced; then lime more or less next time, keeping always on the safe side—that is, the acid side. The liming should cease when the juice gives only a faint red to the litmus. If it does not change the color at all, too much lime has been used, and fresh unlimed juice should be added.

REHEATING.

When a semi-sirup refuses to settle clear, the most effective way of brightening it is to reheat and resettle it. This often makes surprising improvement, and testing the sediment which results from impurities, which would neither rise nor settle, shows that it pays to clean semi-sirup well. The drainage from scums, the liquid part of settlings, and the sweet washings of tanks and pans are reheated and filter-pressed

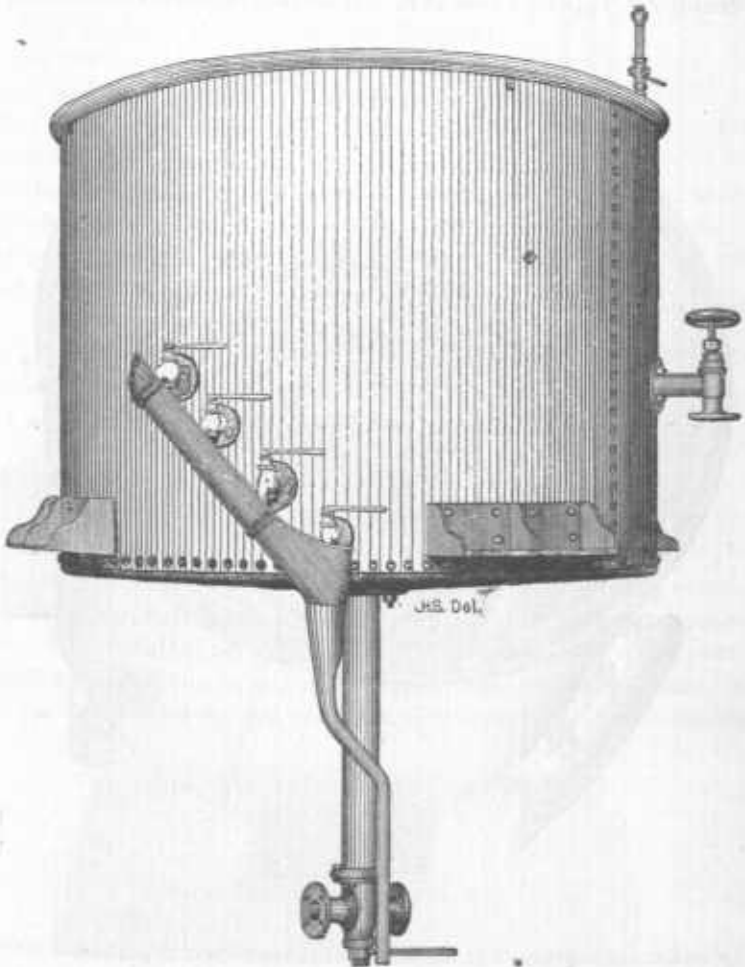


FIG. 13.—Outside view of a steam reheater and settler.

or resettled in good sugar-factory practice. Figs. 13 and 14 show a steam reheater and resettler used in many sugar factories. The scum, etc., are heated to nearly boiling, settled several hours in this reheater, then drawn off by the side valves below the scum and above the sediment until the two are nearly together, and the refuse is then washed out.

Acid juices should not be used with iron or galvanized vessels unless the latter be painted with an acid-proof paint. Wooden buckets are to be preferred to those made of iron for handling the juice.

FILTERING.

When a sample bottle of semi-sirup at 25° density is placed in a strong light and another sample of the same semi-sirup, after claying, settling, and decanting, is placed beside it, the settled sample is seen to be bet-

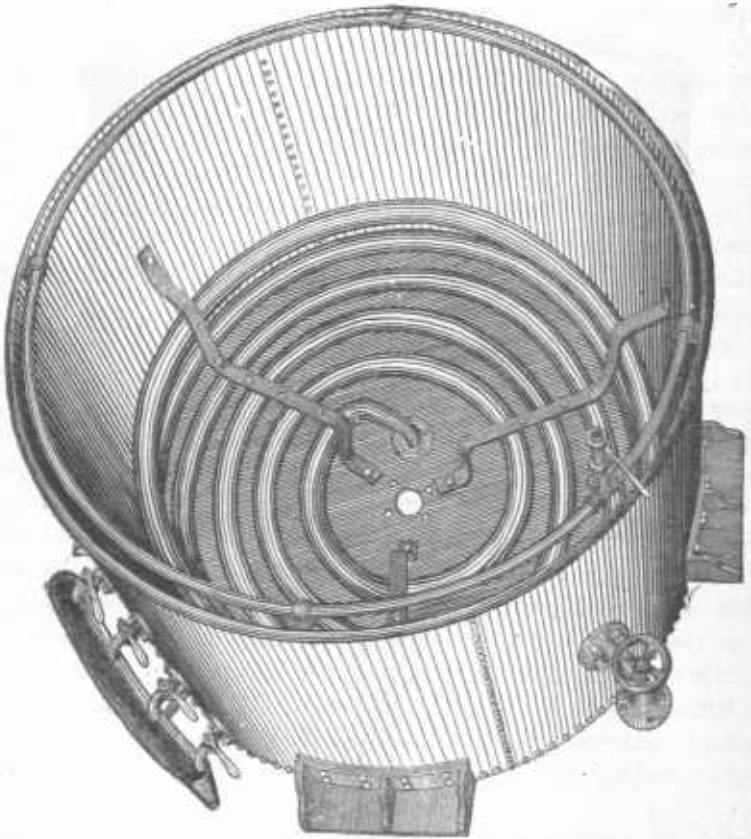


FIG. 14.—Inside view of a steam reheater and settler.

ter in color and clearer; it is also of better flavor. It still contains, however, small particles of suspended matter which settle very slowly, leaving the semi-sirup bright. Sugar refiners and many sugar makers place great stress upon filtering. Sorghum-sirup makers never filter. If filtering is done it must be between the clarified juice and semi-sirup of 27° density. Refiners and sugar makers frequently use bag filters (fig. 15). A bag of twilled cotton, 6 feet long and 2 or 3 feet wide, is folded twice lengthwise and slipped into a strong, loosely

woven sheath, which keeps it in compact form. Many of these bags are placed in a hot chamber and are attached to the bottom of a tank containing the liquid to be filtered. The hot liquid filters through the bags.

The writer has tried many filters and considers that the best for small sirup factories is a sawdust filter, made with coarse sawmill, not planer mill, sawdust, well soaked to extract all color and flavor and placed in a holder with good bottom drainage. A box (fig. 16) with cross slats slightly apart forms the bottom; upon this bottom loosely woven gunny cloth is placed, and upon this 5 or 6 inches of well cleaned and sifted sawdust. The dust is sifted to remove coarse trash, and again sifted to remove fine sawdust, which would cause the filter to clog soon. Decanted semi-sirup of 25° density is improved by this filtration. When clogged the sawdust can be washed and used again. It has been said that sorghum sirup, or sugar, making will never succeed until all the semi-sirup can be well filtered; for a liquid so slimy that it can not be filtered will make unpalatable sirup and will crystallize badly.

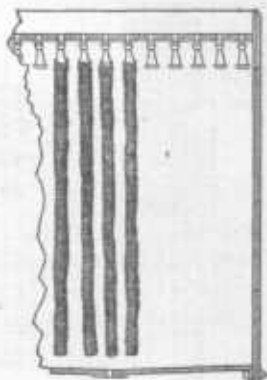


FIG. 15.—Bag filters

SKIMMING.

There are three ways of removing solid impurities from sorghum juice—skimming, settling, and filtering. Each of these ways should be used. Skimming alone removes only a part of the impurity, which, entangled with bubbles of air or of vapor, rises to the surface. The rest of the impurities do not rise, but tend to settle. When the bub-

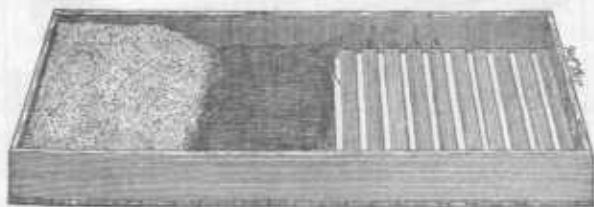


FIG. 16.—A filter box allowing free drainage through the bottom.

bles are broken by stirring or boiling in, the seum disappears and does not rise again. Sirup makers often skim very carefully, yet fail to remove the impurities which spoil the sirup. Better sirup can be made by settling only than by skimming only.

EVAPORATION.

A good evaporator which can be easily cleaned has an influence upon the quality of sirup. Sirup may have been recently emptied out of a pan; the pan may be clean in one sense, yet may not be in good condition to receive more juice, for the film of sirup (foam) and some sediment remaining have been dried until the heating surface is covered

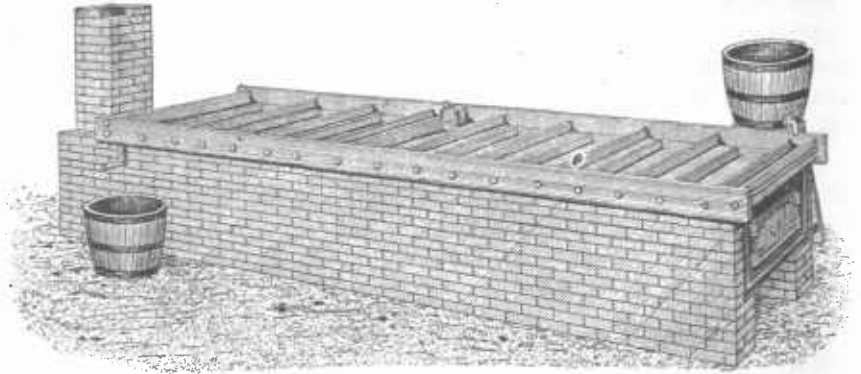


FIG. 17.—A fire evaporator.

with a solid varnish. When cold juice again flows into this pan, this covering of dried molasses dissolves slowly, often burning upon the hot surface and coloring the sirup for several hours after being heated. It is not much trouble to sweep out the pan with a broom and a little water before refilling, or at least to see that the dry matter is redissolved in the fresh juice, to avoid burning.

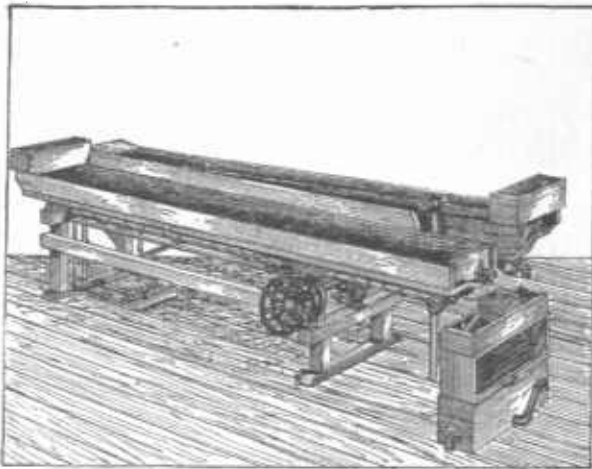


FIG. 18.—A steam evaporator.

A float valve, controlling the flow of juice into the pan, thus regulating the depth of liquor and preventing flooding or burning, is used by maple-sirup makers. It is recommended by sorghum-sirup makers who use it. A fire evaporator is shown in fig. 17 and a steam evaporator in fig. 18.

USE OF CRUSHED CANE AS FUEL.

In the West sun-dried crushed cane is often used as fuel. A sheet-iron funnel tapering toward the end nearest the furnace, so as to slightly compress this light fuel as it is pushed through into the furnace, and having a sheet-iron door hinged to the upper surface, is a safer and better method of firing than to put the crushed canes directly upon the fire. A forkful of the fuel pushes the door inward, and the door closes itself when the fork is withdrawn. In all sugar-cane producing countries the crushed canes are now carried from the mill by an automatic carrier to a special furnace, where they produce nearly or quite sufficient fuel for the factory.

THE SACCHAROMETER.

A saccharometer (fig. 19) is an instrument for showing the density of saccharine liquids. The Baumé instrument is the one referred to in this bulletin. When placed in a tin cup filled with the liquid it floats higher or lower, according to the density of the liquid. Sorghum juice usually shows from 8 to 10 degrees density; thin semi-sirup is 20° density, heavy semi-sirup is 30°, hot finished sirup is 36° to 38°, and cold sirup is about 40° density. If it is found that clayed semi-sirup at 27° density settles slowly and imperfectly, the semi-sirup should be settled at a lower density, say 22° to 25°. More impurity would be thrown out of solution by boiling semi-sirup to 27° or 30° density, and so more impurity would be removed by boiling and settling at 27° to 30° density. But it is usually better to settle the semi-sirup at not more than 25° density. The use of a saccharometer is not essential in conducting the work, but it is a help. The test cup ordinarily used with the saccharometer can be made by a tinner. The writer prefers one not larger than necessary, about 1½ inches in diameter and 9 or 10 inches deep, having a handle, and a shallow pan serving as a foot stand and also receiving the overflow of the cup when the saccharometer is dropped in. In ordering a saccharometer always specify a Baumé instrument, for this scale is almost universally used by sirup makers. The saccharometer is made of glass, is thin and fragile, and is for use in hot or cold liquids. These instruments are also termed "hydrometers" or "spindles." In testing juice fresh from the mill let it stand a while to allow bubbles of air to escape, otherwise the density, as indicated by the saccharometer, will be less than it should be. A table showing the number of gallons of juice of different densities required to make 1 gallon of sirup is given in Mr. Cleland's letter appended.¹



FIG. 19.—A saccharometer and cup.

¹ See p. 38.

SETTLING.

Cold raw juice settles very slowly and imperfectly. Clayed cold raw juice settles better, but takes some time. The settling of hot, clayed juice is rapid, and the settlings are not bulky or wasteful. The settling of hot-clayed semi-sirup varies in the time it requires, according to the density, the liming of the juice, and the temperature of the air and the size of the grain of the clay. Sirup when cooled settles slowly. When semi-sirup is clayed it is well to cover the barrel to retain the heat longer. Some sugar factories which settle all the semi-sirup keep the settling tanks in a hot room, and settle from six to ten hours. It is advisable to give semi-sirup time enough to thoroughly settle: from twelve to twenty-four hours are usually sufficient. It will not ferment in even a much longer time. It is not best to draw off the settled semi-sirup too closely to the settlings. Usually four-fifths of the semi-sirup can be safely decanted; the rest can then be decanted into another vessel, leaving the sediment, which may be put back into the raw-juice tank to be reclarified; or, as is the custom in sugar factories, the bottoms from several tanks may be put together, reheated, and resettled. Sorghum semi-sirup will settle without claying, but claying gives better settling and cleaner semi-sirup. Settling warmed raw clayed juice, or clayed hot juice, or clayed hot semi-sirup, at 25° density, makes much improvement in the quality of the sirup. The settling removes solid matter from raw juice before heating to boiling, solid matter coagulated by heating, and solid matter precipitated during evaporation to 25° density. As the juice has been skimmed as usual, the impurity removed by these settlings is such as can not be removed by skimming.

CLARIPHOS.

Clariphos is a solution containing phosphoric acid and soluble acid calcium phosphate. It is much used by cane-sugar makers. It is not costly nor harmful. It should be kept in glass or in wood. Sugar makers use it in various proportions and in liquor of various densities. The writer prefers to use it in clarified juice, and moderately; for an excess of this acid gives bulky settlings. It must be carefully neutralized with lime. Sugar makers always lime the juice first, then add the acid. For sirup it seems best to add the acid to the juice first, boil a few minutes, then neutralize the excess of acids, and settle.

FILTERING AND COOLING FINISHED SIRUP.

Sirup made by the processes described is when first finished apparently clean, of good color, and has little sorghum flavor. It is not bright or transparent; for it still contains a small amount of impurity

which was thrown out of solution during concentration of the semi-sirup from 25° density to 40° density, cold. If the juice could be limed to full neutrality it would throw out less impurity during the final concentration. When the sirup is first finished the small particles of impurity are invisible. But if a bottle be filled with the fresh sirup and placed in a window it will be seen that in a week or more these invisible particles adhere together, forming larger particles, which very slowly settle in the cold finished sirup, leaving the sirup very clear and bright. Singularly, this final settling of the finished sirup seems not to occur in this product from juice that is not limed, although such sirup has more sorghum flavor and contains more impurity.

It is very desirable to remove from finished sirup all of the solid impurities it may contain. A sirup filter and cooler combined for small factories (fig. 20) may consist of a wooden box 14 inches or more deep, 8 feet long, 3 feet wide, the bottom of sheet iron, well painted. A false bottom of slats, a little apart, or of perforated boards, is placed about 2 inches above the bottom of the box. Its



FIG. 20.—A finished sirup filter, cooler, and storage tank. *a.* Drainage chamber. *b.* Perforated false bottom. *c.* Filtering material. *d.* Loosely woven cloth.

object is to leave a drainage chamber at the bottom, so that the sirup may drain downward from all parts of the box. Upon the false bottom is placed excelsior (wood straw), used in packing goods. It has been recommended to boil the excelsior in a solution of caustic soda before using it, or to soak it well, first in cold water, changing the water, then in hot water. The writer merely soaked the excelsior in a barrel of cold water two or three days, changing the water as often as it showed color or flavor. The object of this is to remove the extractable matter from the excelsior, which would give color and flavor to the sirup. The excelsior can often be had from merchants for the asking, or can be ordered by the bale. The washed excelsior is placed upon the false bottom in the box, a little at a time, closely but not tightly packed, leaving no large open spaces through which the sirup may flow. It is well to place the fibers crosswise to one another, instead of parallel. The box is thus nearly filled with the excelsior. A loosely woven gunny cloth, larger than the box, is placed over the top and hangs down over the sides and ends of the box. This is to strain the hot, finished sirup, removing the gummy foam before it reaches the excelsior. The loosely woven gunny-cloth cover can be washed and replaced as often as may be necessary. A molasses gate, or a plug, is placed near the bottom of the box for drawing the finished sirup from the drainage chamber below the filter. When the filtering

material is clogged in one place the sirup flows down through another part of the filter. This filter box should be always kept nearly full of sirup. The sirup should not be drawn off sooner than necessary. It should be allowed to stand upon the excelsior as long as may be.

If sirup is simply run through the empty filter it will do little good. By standing upon the excelsior the impurities adhere to the wood fiber. By slowly drawing off the filtered sirup the impurities are not carried along with the sirup. It is well to place an empty barrel under the outlet pipe and let the filtered sirup slowly run into it, taking care it does not overflow, meantime running sirup into the filter box, keeping it full. The finished sirup going into this filter should be warm as may be. If much very hot sirup is to be filtered it would be well to cool it a little before it stands in the filter. This filter answers the same purpose as when wine and cider makers and brewers let turbid liquids stand a day or two in a tank filled with clean wood shavings, and then slowly draw off the brightened liquid, the gummy matter adhering to the shavings.

It is said that when the excelsior is clipped into short pieces, like needles, an inch or two long, it packs much more easily in the filter than the long excelsior, leaving fewer open channels for the sirup to flow down, and also being less compact. When the filter has become clogged the excelsior should be drained, then washed in a little water. This sweet water should be put in the raw-juice tank, and the excelsior should be well washed and replaced. The length of time the filter will act before clogging depends upon the care which is taken in cleaning the semi-sirup.

The writer successfully filtered hot, finished sirup through very coarse sifted sand. It is hoped that further experimental work will develop this plan of cleaning finished sirup as the last step in the manufacture. Some European sugar experts assert that sirup of 36° density, hot, can be filtered well through a bed of pure sifted sand with grain of suitable size. River sand usually contains clay, fragments of soft shale, soapstone, etc., which unfits it for this purpose. Pure quartz sand, ready sifted to proper size of grain, costs little.

CANNING SIRUP.

Dealers prefer to handle canned sirups. It is easier to take a can of measured sirup from a shelf than to leave customers and draw a slow-running sirup from a barrel. It often suits customers better to buy a can of sirup of a brand they like than to get sirup of uncertain quality from a barrel. It seems that sirup makers should can their best sirup, always keeping the quality true to the label. Sorghum sirup made without lime or chemicals, with no adulteration, light colored, retaining the natural acids of the juice, should carry a label

stating the facts. Limed sirup, a rich, warm, red color, nearly neutral, clearer and brighter, is preferred by many, and its label should state its quality. The label should bear the maker's name as a guaranty of the quality. Lower grades should be barreled and sold by sample, or inspection, as usual. A can with seal cover is largely used by sugar-cane sirup makers. The stopper of the can carries a rubber band, for use in sealing up the hot sirup. It is claimed that sirup, sealed while hot, can be kept for years, retaining the flavor of newmade sirup, with no fermentation. It is not well to put fine sirup in leaky and stained second-hand barrels. Many manufacturers take great pains to make their goods attractive and put them in attractive packages. Sorghum-sirup makers should follow their example.

CRYSTALLIZATION.

Sorghum juice, from ripe cane, is often rich in crystallizable sugar. Juice from unripe cane, or from cane cut some days before grinding, contains an excess of uncrystallizable sugar. When the slimy impurities are well removed, as by the foregoing processes, the sugar is apt to crystallize when in excess, and if the uncrystallizable sugar is in excess the sirup is apt to "jell" on long standing. The writer knows no way to avoid either of these troubles. The purer and better the sirup, the more likely it is to either "grain" or "jell."¹

MAKING SIRUP ON SHARES.

Many sirup makers manufacture sirup on shares or for a stated price per gallon. It is inconvenient to divide the sirup while the pan is in operation, as more or less is left in the pan or mixed with juice from another lot.

By measuring the juice of one lot, taking its density by a saccharometer, and referring to the table given in Mr. Cleland's letter appended,² the number of gallons of sirup due the cane grower can be learned. For instance, if one lot of cane gave 100 gallons of juice having a density of 10° , one may note by the table that 6 gallons of juice at 10° density make 1 gallon of sirup; hence 100 gallons should make $16\frac{2}{3}$ gallons of sirup. In this way as soon as a separate lot of cane is ground the juice can be measured, the density taken, and the number of gallons of sirup due the cane grower can be learned without interfering with the work of the evaporator.

¹ The formation of the jelly-like body mentioned is due to a viscous fermentation.—H. W. W.

² See p. 39.

DECANTING DEVICES.

Fig. 9 shows a half-barrel settling tub used many times successfully by the writer in pouring off hot, clayed, settled juice from the surface, leaving the sediment. Tipping the tub must be done gently to avoid disturbing the settlings, and the juice should be poured off slowly,

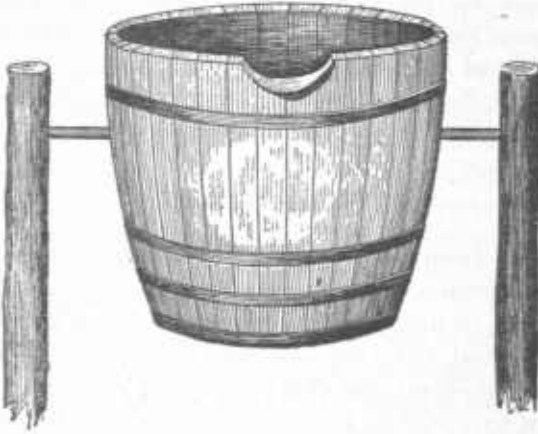


FIG. 21.—A swinging barrel for easily pouring off settled juice.

watching the outlet to see that the settlings are not poured off. In pouring off slowly the juice is apt to run down the outside of the tub. To prevent this a notch, A, an inch deep and 4 inches wide, is cut in the upper end of the staves and a straight piece of tin is tacked to the

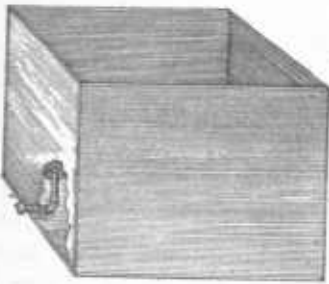


FIG. 22.—A settling tank from which the clear liquid is drawn by an upright nipple near the bottom.

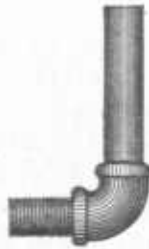


FIG. 23.—A swing pipe for decanting liquids.

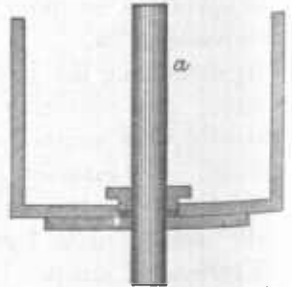


FIG. 24.—A sliding overflow pipe for decanting liquids.

sides of the notch, forming a pouring lip, which projects an inch outside the tub. It is well to tip the tub a little toward the pouring lip, by placing a block under the opposite side, before filling with the liquid, as it is easier than to tip the filled tub gently.

Fig. 21 shows a barrel having a tin lip and hung so that the clean liquid may be more easily poured off.

Fig. 22 shows a tank, having an outlet for liquid near the bottom. The valve is cautiously opened, and the turbid liquid first flowing out is turned into a small vessel; when the liquid comes clear it is turned into its proper tank. This plan is used by sugar factories.

Fig. 23 presents a swing pipe, consisting of a short nipple, an elbow, and a long arm.

Fig. 24 shows a sliding overflow pipe, which passes through the bottom of the settling tank by pushing the pipe down, so that its upper end is below the surface of the liquid; the liquid is drawn from the surface. This device was used in a sugar factory which worked 1,000 tons of cane in a day.



FIG. 25.—An outside swing pipe for drawing liquid from the bottom.

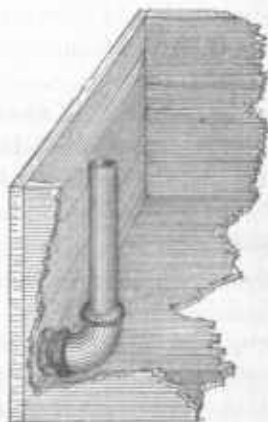


FIG. 26.—An inside swing pipe for decanting liquids from near the surface.

Fig. 25 is an outside swing pipe, which draws the liquid from the bottom of the tank. By turning the long arm down, the liquid flows out; by turning it up, the flow ceases.

Fig. 26 shows an inside swing pipe for drawing liquid from near the surface, leaving the sediment by keeping the upper end of the long arm just below the surface of the liquid. A float, carrying the end of the long arm, keeping it just below the surface of the liquid, and arranged so as not to draw the settlings, may be successfully used. The writer prefers to use a swing pipe, made of $1\frac{1}{4}$ -inch pipe. The arm must be long enough to reach above the surface of the liquid in the settling tank, and the swing pipe should be placed close to the bottom of the tank, far enough from the side to allow the long arm when turned down entirely to lie flat upon the bottom, so as to draw all the liquid out of the tank; the long arm of the nipple should fit the threads tightly enough to hold the weight of the pipe in any position, not dropping down when left alone.

SIRUP ITEMS.

In Java, a box, open at the top, with a strainer at the bottom, filled with palm-leaf fiber, filters mill juice well.

The Florida Agricultural Experiment Station recommends filtering sugar-cane mill juice through 2 feet of tightly packed Spanish moss. This is said to improve the sirup considerably.

Never heat sugar-cane juice to boiling before clarifying. Certain impurities which dissolve at the boiling point can be settled out below that temperature.

Sirup from unlined juice is never so clear and bright as that from properly lined juice. Sirup from lined juice is not so light in color nor so acid as that from unlined juice.

Alterations of temperature favor settling of semi-sirup, and reheating and resettling often clears turbid semi-sirups.

At a Cuban plantation the juice is partly lined before heating, again lined after heating before settling. In decanting, a flexible float pipe follows the liquid down. Settlings are reheated, settled, and decanted.

Louisiana sugar factories usually heat, skim, settle, and decant the juice, and evaporate it to 22° to 25° density and settle the hot semi-sirup from 6 to 12 hours. All scums and settlings are reheated and settled.

In a San Domingo sugar factory the juice is heated, skimmed, settled, decanted, and boiled to 27° to 30° density, settled until cool, decanted, and finished.

In the Philippine Islands the juice is lined, a little at a time, at intervals, boiled to about 27° density, and settled twenty-four hours; scums and settlings are reheated and settled.

There is loss of heat and there is some work in settling and cooling, but very many large sugar factories do so and find profit in so doing.

Nothing is gained and there is loss in decanting semi-sirup too closely to the settlings. In settling, decant clear liquid when needed and leave the remainder to settle longer.

Sirup from the top of a tank or barrel which has stood undisturbed for a month is of better quality than the rest.

Heat coagulates or flocculates clay, causing it to settle better. A little lime in the clay mortar also improves the settling.

Never keep cold juice, semi-sirup, or sirup long in iron or galvanized iron unless the container is well painted.

A filter which removes much impurity clogs soon. A filter which never clogs does no good. Slow filtering and slow settling give clearer liquids.

Thin semi-sirup, 20° density, settles sooner and can be drawn off closer than heavy semi-sirup at 27° to 30° density, but thin semi-sirup will throw out some more solid impurity by after concentration.

A wooden tank is better for settling semi-sirup than an iron one, because the liquor cools more slowly. It is better to cover a barrel containing hot elayed semi-sirup, to retain heat.

When well skimmed, semi-sirup is let stand twenty-four to forty-eight hours, its settlings are dark in color, and of a bad flavor. The settled semi-sirup is improved.

It is better not to boil clay in the juice and not to add clay in the heater, but to run the hot juice into a settler, then elay and settle.

Rapid boiling is best, because it tends to lessen settling of slimes and burning upon the heating surface. Well-cleaned juice may be boiled more slowly than turbid juice, with less damage to the resulting sirup.

SUMMARY.

Sorghum has as wide a range of latitude as Indian corn. The juice always contains a colorless solution of crystallizable and uncrystallizable sugar, mixed with vegetable and mineral impurities, which are partly in solution and partly in suspension in solid form. The variable quality of sorghum sirup is not due so much to a variable amount of true and good sirup-making material as it is to the variable amount of impurity in the juice.

It seems to be true that almost any soil in any section of the country produces sorghum which has sufficient crystallizable and uncrystallizable sugar to produce good sirup if the impurity is well removed from the juice before heating and also during concentration to finished sirup.

There is no generally accepted opinion in regard to the selection of varieties for sirup manufacture in any section, except that Early Amber is preferred for early cane. A variety may give good sirup in one season and poor sirup in another season, yet have sufficient good sirup-making material in its juice in both seasons, with variable amount of impurity. The way to make selection of varieties is to remove impurities which conceal the true qualities of each variety.

Growing cane by sirup makers should be with a view to obtaining purer juice. Sugar-cane and sugar-beet growers take much care in the selection of varieties and in cultural work, yet they have plants yielding naturally purer juices than that of the sorghum cane.

Clarification of the juice determines the quality of the sirup. When well done the sirup is equal to any cane sirup. When imperfectly done the sirup is of poor quality, dark color, and rank flavor.

Impurities which were in solution in the juice appear in solid form continuously during evaporation. The same is true of sugar-cane juice and of beet juice in less degree.

The processes recommended are: To remove solid impurities from cold juice or from warmed juice by settling before heating to the boiling point; to remove coagulated impurities from hot juice by skimming

and by settling; to remove impurities thrown out of solution during concentration to 25° density by skimming and by settling; and to remove, as well as may be, the small amount of impurity thrown out of solution during concentration from 25° to 36° density, the density of finished sirup.

In addition to these processes, filtering decanted semi-sirup at 25° density is suggested.

Claying warmed raw juice and hot juice and hot semi-sirup is recommended as giving better settling.

Adding a small quantity of lime to the clay used is recommended as assisting in settling.

Adding lime to juice until it is but slightly acid is recommended as giving less acid and brighter sirup, preferred by most persons, though of darker color.

Reheating, settling, and decanting turbid semi-sirups is advised.

The use of clariphos, or phosphoric acid, is not now advised in small sirup factories.

The use of a sirup saccharometer is approved.

Canning the best sirup, using labels bearing the sirup maker's address, is favored.

The processes described in these pages improve sorghum sirup in color, flavor, and clearness. It is reasonable to suppose they may be simplified and perhaps improved by further experimental work.

The following condensed statements give the methods of sorghum-sirup makers in the States named:

CONDENSED STATEMENTS OF SORGHUM-SIRUP MAKERS.

ILLINOIS.

I have been making sirup for thirty years, and now make from 5,000 to 6,000 gallons a year. Cane yields better sirup and more seed when planted in rows both ways with a 2-horse planter. The holes in the drill plates can be filled with melted shot, then bored out with a one-fourth-inch bit, so as to drop from 4 to 6 seeds of the large, late varieties and from 6 to 8 seeds of the Early Amber. Seeds should be tested before planting, so as to plant accordingly. Our main crop is Late Orange. It stands well and makes light-colored sirup. The best cane I have ever grown is Cuban cane, later than Amber and earlier than Late Orange. It has produced from 150 to 175 gallons of sirup and from 30 to 40 bushels of seed to the acre. It has made fine sirup. Early in the season we cut cane twenty-four hours before grinding, to wilt the leaves; use a binder harvester, binding in small bundles. The bundles are topped as they lie upon the ground, leaving the piles of seed to be gathered later. The cane is hauled on low wagons with flat frames. A stout rope is doubled, both ends tied to the hind axle; the doubled rope goes under the cane to the front end, then back over the load, the two ropes being from 2 to 3 feet apart. When at the mill the team is hitched to the upper ropes, which pulls the load off better than can be done by hand. The seed tops lie in the field until cured and are thrashed by machine. There is about as much money in the seed as in the sirup.

We have used the clay settling process described in Farmers' Bulletin No. 90. It makes much improvement in the color and flavor of the sirup. We use a steam jet to pump the juice from the mill to the settling tanks. It warms the juice so it settles much better than cold juice. We use a yellow clay. It settles soon and leaves the juice clean. Then the juice goes to the defecator, is heated by steam, skimmed, reheated a time or two to throw up scum, then into a settling tank, where it settles an hour or two; then into an evaporator, where it is boiled to about 25° density; then into a finisher, where it is boiled to 36 to 38 density, hot; and thence into shallow coolers. We sell to merchants, and sold 110 barrels last season before the last of January. We are pleased with the clay process. We used the old process one week last season. The sirup was dark and strong; quite different from that by the new process. We have no wish to make sirup without claying and settling the raw juice.—W. O. DENNY.

We plant little cane before May 15; clear all trash off the land, plow, drop 80 to 90 seeds to the rod of row, harrow both ways after planting, cultivate with "eagle claws," and cut the cane with a corn harvester. We do not strip cane, but cut one or two days before rolling.

We use lime and clay, settle, and filter before pumping juice to defecators, where it stands an hour or more. We use clay in hot defecated juice with very good results. We will continue right along this line the coming season. We make 50 to 70 gallons of sirup an hour. We grow cane, and also make sirup for others at 15 cents a gallon. We sell to retail grocers. Those who make good sirup err in allowing it to get into the hands of mixers.—L. W. CUSHMAN SIRUP COMPANY.

SOUTH DAKOTA.

I fall plow stubble ground early; in the spring disk and then harrow. I plant one-third of my crop as soon as the land is in good condition, 1st to 10th of May; another one-third ten days later, the rest the last of May, so the whole crop will not need working and will not mature at once. I plant 6 or 8 seeds in hills every 22 inches, an inch deep; about five days after go over with a smoothing harrow. I have planted Early Amber for twenty years; hoe and thin it to 5 or 6 plants and use a surface cultivator. I use a Stubbs pan, and make 3,000 to 4,000 gallons of sirup a year. I make about 250 gallons of sirup and raise about 30 bushels of seed per acre.—C. F. FENNEL.

TEXAS.

I make about 3,000 gallons of sirup in a season. The Early Amber is best for early cane. It will produce three crops in a year, the third crop for forage. The Red Top African variety is best. It is large and remains good longer in the field. We plant after corn is planted, rows 3½ feet wide, cane thinned to 4 inches apart. When well started a light harrow is used. In eight or ten days another harrowing, then two shallow cultivations. The canes are stripped and cut and piled across the rows. The mill juice is filtered upward through straw. I have worked in the old way of making sirup. We get heavy crops of cane; sirup of dark color and of rank flavor. Last year I settled the cold mill juice with clay, which gave better sirup. The past season I settled the hot juice with clay. This is the better way. The coming season I hope also to clay and settle the semi-sirup, which is said to give much better sirup. I add one-fourth ounce of carbonate of magnesia to 100 gallons of juice to reduce acidity, heat, skim, then run it into a long shallow pan, clay it, settle thirty minutes, draw off the settled juice from the surface with a swing pipe, run the settlings into a tub to resettle, evaporate the clean juice to semi-sirup, then run it into a finisher which can be removed from the fire, and cool the sirup in a shallow pan.—T. R. RUSSELL.

KANSAS.

Sorghum juice was impure here last season. Kansas Orange and Silver Tip made best sirup. Capacity of mill, 200 gallons of sirup in twelve hours. Use natural gas as fuel. Toward the close of the season we clayed and settled the hot semi-sirup at 25° density with very satisfactory results. We made good sirup from juice so impure we could do nothing with it in the old way.—J. W. HAMM.

I plow deep after weeds start; soon as plowed put three horses to heavy planks nailed together. Ride upon this. It is much better than harrowing. Mark three rows at a time; then plant with a one-horse drill, dropping 2 or 3 seeds each 8 inches; cultivate 1 inch deep soon as rows can be followed. Cultivate with small shovels; go slow and carefully, close to the row. When this is well done the crop is half tended. Cultivate two or three times more, not ridging the rows too much. When cut, load the cane with heads all one way and even, hanging over the side of the frame, drive to a convenient place, and then top the cane with a corn or hay knife. Have no seed tops to pick up in the field. Drive to the mill and pull the cane off with the team. I do not strip cane. Crush as soon as cut, pump the juice into a settling tank, then to a defecator, where it is heated and settled. I can boil 40 gallons of sirup in an hour. Use elariphos in the defecator, then line the juice, and boil it a few minutes. The scum and impurities settle in about thirty minutes. Evaporate with steam at 80 pounds, and cool in a trough in water.—E. HANSFORD.

Last season our cane crop was limited. We worked 4,000 tons of cane; made 80,000 gallons of sirup, 42° density, cold; about one month's full run. Can handle 150 tons of cane and make 3,000 gallons of sirup in a day, getting 20 gallons of heavy sirup from a ton of field cane. We expect to pay \$1.50 a ton for cane and \$3 a ton for seed tops next season.—R. BEST.

I can make 700 to 800 gallons of sirup in ten hours. I plow after weeds start, and harrow. I get an even stand and never replant, thus getting a heavier crop two weeks earlier. With listing one never knows when he is through replanting, and a lister always plants too much seed. I plant one seed every 3 or 4 inches in a row, and cover 1 inch deep. I cultivate soon as rows can be seen. I never hoe or thin. I cut cane with a harvester, top immediately, and let the cane lie in the field from four to six days. Cane ground the day it is cut is apt to produce sugar. I let the juice run through a long, wide, shallow pan. The juice goes in at one end all day and is drawn off at the other end all day, settling as it flows. I get much sediment from this pan or trough each day; the longer the trough is the better. The pan should be well washed each day. I boil in a long steam pan, steam at 100 pounds pressure. The most deficient part of my work is in cooling the sirup. Sirup should not be stirred while cooling, or after cooling, as it is more likely to crystallize.—WILLIAM SEMKE.

INDIANA.

The Early Amber is the best variety here. Folger's Early did very well last year. Cane is cultivated the same as corn, except that some hoe and thin it to 7 or 8 stalks to the hill. I let cane lie in the yard three or four days, and am not bothered with sugar. I weigh the cane and give from 10 to 17 gallons of sirup to a ton of cane. I expect to buy cane at \$2 a ton. I use a steam mill, and make 5,000 or 6,000 gallons of sirup a year. Sold all I made in 1900 at 35 to 40 cents a gallon. I run the raw juice from the mill through a box 8 feet long, having four partitions crosswise. The juice flows under the first partition, over the second, under the third, and over the fourth, arresting all floating impurities and holding back the settlings. To 100 gallons of the juice I add 1 pint of bisulphite of lime while the tank is filling. When full I put in 1 quart of milk of lime. If the sirup is too ~~dark~~ I add more bisulphite

of lime; if too light I add more lime next time. I let the juice settle twenty to sixty minutes. I let the clarified juice run in a continual stream into a fire evaporator 24 feet long. I use wood or coal under the pan, and also use a small steam coil in the finishing end of the pan in addition to the heat underneath. It finishes the sirup in a hurry. Then the finished sirup runs through a long galvanized iron trough, 18 inches wide, which quickly cools it. It is light in color and of good flavor.

When making sirup for others the mill juice is measured in the juice tank, which has a vertical glass tube connected with it, on the outside of the tank, so that the juice stands at the same level in the tube as in the tank. By the side of this gauge is a scale, showing the number of gallons of juice in the tank. The density of juice is taken by a saccharometer. Then, by the following table, the number of gallons of sirup due the cane grower is calculated:

With juice of 6° density 10 gallons of juice produce 1 gallon of sirup.

With juice of 6½° density 9 gallons of juice produce 1 gallon of sirup.

With juice of 7° density 8½ gallons of juice produce 1 gallon of sirup.

With juice of 7½° density 8 gallons of juice produce 1 gallon of sirup.

With juice of 8½° density 7 gallons of juice produce 1 gallon of sirup.

With juice of 9° density 6½ gallons of juice produce 1 gallon of sirup.

With juice of 10° density 6 gallons of juice produce 1 gallon of sirup.

With juice of 11° density 5½ gallons of juice produce 1 gallon of sirup.

With juice of 12° density 5 gallons of juice produce 1 gallon of sirup.

As an example, 100 gallons of juice having 10° density give 16⅔ gallons of sirup. The same quantity of juice at 6° density gives 10 gallons of sirup. By this method the operation of the pan is not hindered. The number of gallons of sirup due the cane grower is known as the cane is ground.—A. P. CLELAND.

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